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OBTAINING FEEDBACK ON THE LIFE CYCLE COST ANALYSIS OF THE STANDARD ENGINE TEST SYSTEM

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OBTAINING FEEDBACK ON THE LIFE CYCLE COST ANALYSIS OF THE STANDARD ENGINE TEST SYSTEM

The Naval Air Warfare Center Aircraft Division is the cognizant field activity for the Navy's engine test systems. The Cost Analysis and Estimating Section completed a life cycle cost analysis for the Standard Engine Test Systems (SETS) which is the Navy's latest generation engine test system. A conservative LCC savings estimate of $862M was generated even though the acquisition cost for the sets is much higher than the acquisition cost for the engine test systems that it replaces.

Determining the accuracy of a LCC analysis is important. Generation of cost element relationships (CER), quality data bases, and proper calibration of costs estimating processes is important to ensure the validity of future estimates and maintaining the confidence of the program managers.

This paper will focus on the verification of the results of the initial report and offer a comparison between the expected and actual life cycle costs. The lead time for support equipment is shorter than many of the larger more complex systems and products, thereby allowing us the ability to develop cost performance measurement results. The presentation will conclude with a "lessons learned" discussion for LCC analyses.

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30 Jul 93

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1. INTRODUCTION

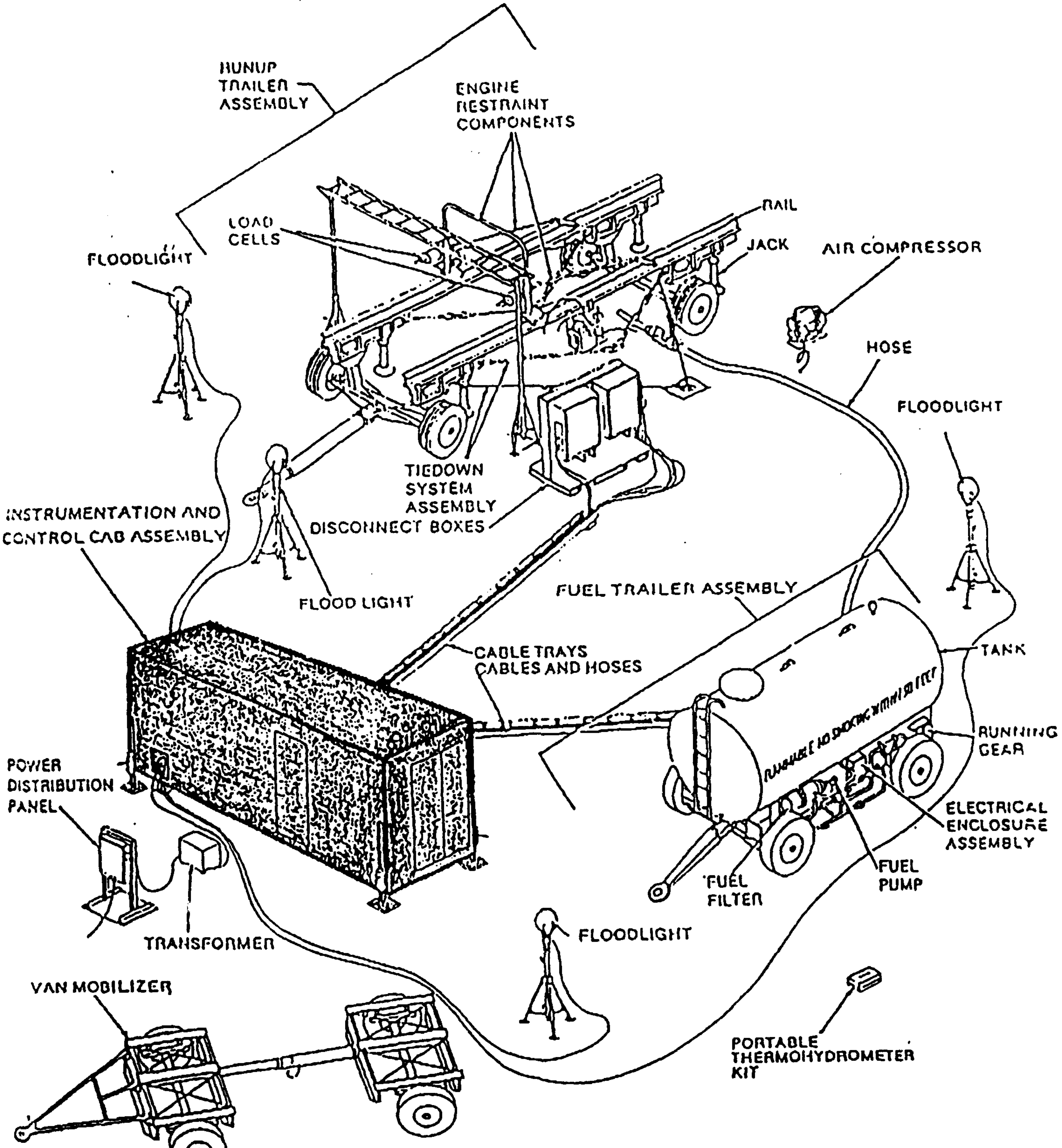
Life Cycle Cost (LCC) estimating have become an increasingly important part of the DoD acquisition approval process. This is especially true under the DoD 5000 Series instructions. In addition to traditional techniques of LCC estimating, the use of Parametric Modeling has increased due to the availability of the Personal Computer (PC). While much research has been done to develop Parametrics, the authors maintain that there is a need for the cost analysis community to review the actual results of each Life Cycle Cost (LCC) in order to improve each new estimate. With ACAT I through IV programs, obtaining feedback on the initial LCC estimate takes years. This is due to the long approval cycle, development, production, and logistics lead times. It can also be noted that the complexity and cost of the typical DoD program is increasing. At this point in time, there is a lack of programs which have had LCC estimates performed using parametric modeling on the PC which are ready to have the results examined.

2. SETS HISTORY

The Naval Air Warfare Center Aircraft Division Lakehurst (NAWCADLKE) is the Cognizant Field Activity (CFA) for Navy Engine Test Systems (ETS). Navy aircraft engine maintenance is performed under the OPNAVINST 4790.2 series and is performed at Organization, Intermediate, and Depot levels. A significant amount of money has been spent on engine test systems at I level since the gas turbine engine replaced reciprocating engines in Navy aircraft.

By the late 1980's, it was becoming apparent that a large number of the test systems were becoming obsolete and would require replacing by the year 2000. As seen in figure 1, many of the components in a typical test system are functionally the same. A standard replacement for all of the test systems needed

STANDARD ENGINE TEST SYSTEM OPERATIONAL LAYOUT



ASE SETS
SEE SHADED AREA

(ALL EXISTING HARDWARE AND CABLE SYSTEMS REMAIN UNCHANGED.)

study. In 1990, the first Life Cycle Cost (LCC) analysis for the Standard Engine Test System (SETS) was performed and showed a significant cost savings to the Navy if a standardized engine test system were developed. The main life cycle cost savers were manpower and fuel although other areas also showed savings.

To provide state-of-the-art capability for testing current and future turbine engines, a Standard Engine Test System (SETS) was proposed to replace existing U.S. Navy aircraft ETS. The 1990 report, which was revised in 1991, provided a life cycle cost analysis of the proposed SETS versus the current test cell equipment. A value analysis of the existing ETS was also presented. The report also included a cost estimate for developing one (1) SETS prototype and producing of 132 SETS units. It addressed the method of cost estimating employed, defines the cost categories examined, provided a comprehensive analyses, and confirmed reported conclusions. A 1991 report gave a fuel consumption estimate for the SETS.

3. TEST STAND HARDWARE

The SETS is the first of a new generation of I-level engine test equipment capable of testing all types of gas turbine engines including turbojet, turbofan, turboshaft, turboprop, APUs, GTCs, etc. It consists of a programmable engine control system, as well as interface adapters, cable assemblies, and engine adapters and stands. The SETS has the capability of operating in a closed-loop (automatic) mode, open-loop (manual) mode, or in a "follow-me" mode depending upon software capability, operator preference, or local test procedure/ requirements. The operator control panels on the SETS consists of toggles, push-button switches, and a touch screen "soft" engine control module (SECM). As the engine is operated throughout its performance envelope, data points are monitored and stored in the computer memory to be printed out and plotted at the completion of the test run. Two 19-inch high-resolution color monitors provide the operators with precise digital and graphic displays of all parameters which require monitoring.

The SETS is an outgrowth of Engineering Specification 1290, which defined the requirements for an Integrated Computer Automated Test System (ICATS) for the Joint Services Cruise Missile Program. The heart of the ICATS is the Automatic Data Acquisition and Processing System (ADAPS), an engine test control system already in wide commercial use for automated testing of gas-turbine engines. The main design effort of the SETS is to revise and repackage the ADAPS into the SETS configuration. Modification of the ADAPS include:

a. Engine Control Module (ECM) - A soft (programmable) engine control module (SECM) must be designed and integrated into the ADAPS system in order to test different engine types.

b. Facilities Control Module (FCM) - The FCM must be modified so that it is capable of controlling all non engine sub-assemblies and support equipment used in conjunction with the engine during engine test.

c. Junction Box - The junction box/engine interface panel must be changed to the common Navy design as delineated by drawing 604AS401 for the purpose of using existing Navy engine umbilical cable assemblies.

d. Shelter - A portable shelter to house the SETS's Instrumentation and Control Console Assembly and other facilities related subsystems.

4. TEST STANDS

At the present time, there are a total of twenty two (22) different engine test systems in the Navy inventory. These systems are given as figure 2 below and exclude Navy depot engine test systems, which are beyond the scope of this report.

ENGINE TEST SYSTEMS

ENGINE TYPE	TEST SYSTEM
TURBOFAN/JET ETS	A/W37T-1 A/F32T-6 A/F32T-6A A/F32T-9 A/F32T-10 A/F32T-11 A/E37T-14 A/M37T-23
TURBOSHAFT ETS	A/W37T-2 A/F37T-16 (V1-V4) A/M37T-17 (V) A/M37T-18 A/E37T-24 (V2-V6) 21C1250 21C2027 21C2222
TURBOPROP ETS	A/E37T-17 (V) A/F37T-19 (V1)
SMALL GAS TURBINE ETS	A/E37T-20 A/E37T-20A A/E37T-26 A/E37T-26A

FIGURE 2

Figure 3 below gives the engines that were proposed to be tested on the SETS at the time that the original LCC report was written. Due to uncertainty at the time the report was written, engines such as the J57, J60, and J79 were included in the report. The F-405 engine was excluded because the T-45 aircraft program is using contractor support. It is possible, but still not decided if the SETS will be used to support the F-405 engine at a later date.

ENGINES TO BE TESTED ON SETS

ENGINE TYPE	ENGINE
TURBOJET	J52 J57 J60 J69 J79 J85 DART MK5298X M861 YJ400-WR-400
TURBOFAN	TF30 TF34 TF41 F110 F402 F412 JT8D-9 F404 CFM56
TURBOPROP	T56 PT6A
TURBOSHAFT	T53 T58 T64 T406 T700
APU & GTC	GTCP36-200/201 T-62T-11/27 T-62T-40-1 T-62T-46-1 T-62T-47-1 GTC95-2 LUCAS MK II/IV

Figure 3

5. SETS LIFE CYCLE COST

The methodology for determining the SETS LCC is provided as appendix A of this report. A combination of analogy and parametric based techniques were used. Results of the estimate are given as figure 4 below.

SETS LIFE CYCLE COSTS

FY	EQPT DEV & SOFT WARE	EQPT PROD	SUPPLY SPARES REPAIR PARTS	SUPPLY ADMIN	MANPOWER & CORRECTIV MAINT	PREVENT MAINT	ON-SITE CAL	SUP FAC	SHIP & HANDL	CONTR SUPP & TRAIN	MODIF & TECH EVAL	ADD SOFT WARE PROGS	ILS MONITOR	FUEL	TOTAL
1990	678	0	3317	297	14740	372	1674	1059	115	0	0	0	80	22274	44606
1991	1279	0	3523	314	15580	396	1781	1119	123	0	0	0	85	23543	47743
1992	524	0	3742	334	16577	423	1900	1191	131	15	136	0	91	25050	50114
1993	0	0	3974	355	17656	449	2020	1268	174	50	0	0	97	26728	52771
1994	0	9412	4220	377	18760	477	2145	1348	148	0	0	0	103	28412	65402
1995	0	7384	4748	360	16704	451	2032	1217	316	0	0	245	0	25848	59305
1996	0	11076	4186	369	15831	422	1896	1104	291	0	0	260	0	22856	58291
1997	0	22891	3081	269	12569	355	1595	737	356	0	0	276	0	16955	59084
1998	0	0	1366	107	8519	287	1291	149	8	0	0	293	0	8550	20570
1999	0	0	1450	114	9047	305	1371	158	8	0	0	312	0	9080	21845
2000	0	0	1540	121	9608	324	1456	168	9	0	938	166	0	9643	23973
2001	0	0	1636	128	10204	344	1546	178	10	0	0	176	0	10240	24462
2002	0	0	1737	136	10836	365	1642	190	10	0	0	187	0	10875	25978
2003	0	0	1845	145	11508	388	1744	201	11	0	0	198	0	11550	27590
2004	0	0	1959	154	12222	412	1852	214	11	0	795	211	0	12266	30096
2005	0	0	2081	163	12980	437	1967	227	12	0	0	224	0	13026	31117
2006	0	0	2210	173	13784	464	2089	241	13	0	0	238	0	13834	33046
2007	0	0	2347	184	14639	493	2218	256	14	0	0	252	0	14691	35094
2008	0	0	2492	195	15547	524	2356	272	15	0	1012	268	0	15602	38283
2009	0	0	2647	207	16510	556	2502	289	16	0	0	285	0	16570	39582
TOTAL	2481	50763	54101	4502	273821	8244	37077	11586	1791	65	2881	3591	456	337593	788952

FIGURE 4

The proposed development procurement was for engineering design services to modify the existing ADAPS data package for SETS requirement, a deliverable level 3 data package of the modified system, and a prototype system to verify the design. The level 3 data package acquired will ultimately be used for procurement of follow on production. The follow on production units are expected to be procured through open competition. The milestone chart of the SETS is provided in Appendix D.

Life cycle cost refers to all costs associated with a system throughout a defined life cycle. The life cycle for the study of the SETS began in 1990 with the developmental phase. Production is scheduled to start in 1994. Operation and support will be 15 years beginning 1994. Life cycle cost definitions are given as Appendix C.

6. STATUS QUO COST

The methodology for determining the status quo LCC is provided as appendix A of this report. A combination of analogy and parametric based techniques were used. Results of the estimate are given as figure 5 below.

ETS LIFE CYCLE COSTS

FY	SUPPLY SPARES REPAIR PARTS	SUPPLY ADMIN	MANPOWER & CORRECTIV MAINT	PREVENT MAINT	ON-SITE CAL	SUP FAC	SHIP & HANDL	FUEL	TOTAL
1990	3317	297	14740	372	1674	1059	115	22274	43848
1991	3523	314	15580	396	1781	1119	123	23543	46379
1992	3742	334	16577	423	1900	1191	131	25050	49348
1993	3974	355	17656	449	2020	1268	139	26728	52589
1994	4220	377	18760	477	2145	1348	148	28412	55887
1995	4482	401	19923	507	2278	1431	157	30174	59353
1996	4759	426	21158	538	2420	1520	167	32044	63032
1997	5054	452	22470	572	2570	1614	177	34031	66940
1998	5368	480	23863	607	2729	1714	188	36141	71090
1999	5701	510	25343	645	2898	1820	200	38382	75499
2000	6054	541	26914	685	3078	1933	212	40762	80179
2001	6429	575	28583	727	3269	2053	225	43289	85150
2002	6828	610	30355	772	3471	2180	239	45973	90428
2003	7251	648	32237	820	3687	2315	254	48823	96035
2004	7701	688	34235	871	3915	2459	270	51850	101989
2005	8178	731	36358	925	4158	2611	287	55065	108313
2006	8686	776	38612	982	4416	2773	305	58479	115029
2007	9224	824	41006	1043	4690	2945	323	62104	122159
2008	9796	876	43548	1108	4980	3128	343	65955	129734
2009	10403	930	46248	1177	5289	3322	365	70044	137778
TOTAL	124690	11145	554166	14096	63368	39803	4368	839123	1650759

FIGURE 5

Figures 6 and 7 give the quantities of existing test systems in use today. These figures do not include base closures and carrier decommissionings.

LAND BASED ETS INVENTORY

ETS'S ON SITE	NUMBER OF LAND BASED ACTIVITIES
14	1
10	2
9	1
8	2
7	7
6	7
5	9
4	4
3	6
2	10
1	4
TOTAL	253

FIGURE 6

CARRIER BASED ETS INVENTORY

ETS'S ON CARRIER	NUMBER OF CARRIERS
2	9
1	8
TOTAL	26

FIGURE 7

Fuel Cost Savings

To determine the potential fuel cost savings of the SETS over the existing ETS, the following informations and assumptions as documented in NAEC-MISC-52-1055 were utilized:

1) The SETS run time will be 3.1 hr/run. (includes set up & break down time)

2) The existing test system run time is 4.3 hr/run. (includes set up & break down time)

3) The Total Items Processed (TIP) is 66,960.

4) There are 279 existing test cells.

5) 132 SETS are to be manufactured.

6) The SETS will replace existing units in a 2.5:1 ratio.

7) The average aircraft engine, fuel flow turbine will consume 2.8 GPM/168 GPH/1142.4 PPH.

8) Inflation rates generated by the cost model were applied.

Data for existing land based test systems was used to calculate average values. According to NAEC-DESDAT-52-742, the mean test time of the SETS will be 1.1 hours. The existing test systems have a mean test time of 2.2 hours. This represents a 50% reduction in test time for the SETS. Using the aforementioned informations and assumptions, the yearly fuel usage rates were calculated. It is estimated that by utilizing the SETS in the 20 year life cycle would result in a fuel cost savings of approximately $501,530,000.00.

7. SETS DECISION

As can be seen in figure 8 below, there is a significant cost savings to the Navy by retiring the existing test systems and procuring the SETS. The need for the Standard Engine Test System (SETS) is twofold. First, the Navy calls for fleet I-level maintenance activities to have out-of-airframe engine runup capabilities; various engine test systems are currently in the inventory to fulfill this requirement. In accordance with the engine test system Program Element Master Plan's (PEMP), the majority of existing support equipment used for out-of-airframe engine testing will have exceeded its useful service life by the year 2000. Subsequently, it is more cost effective to provide Fleet activities with new engine test equipment rather than support and upgrade out dated engine test equipment currently in the inventory. Secondly, the technology of engines now being bought for the Fleet (i.e. F110-GE-400. F404-GE-F5D2, T406-AD-400, etc.) demands digital signal interface between the engine test system and the engine control unit (ECU). All existing engine test equipment process only analog signals. Upgrades to provide digital signal processing (see section on adaptor assemblies in this report) is not cost effective. The total LCC savings realized by procuring the SETS is estimated to be $861,807,000.

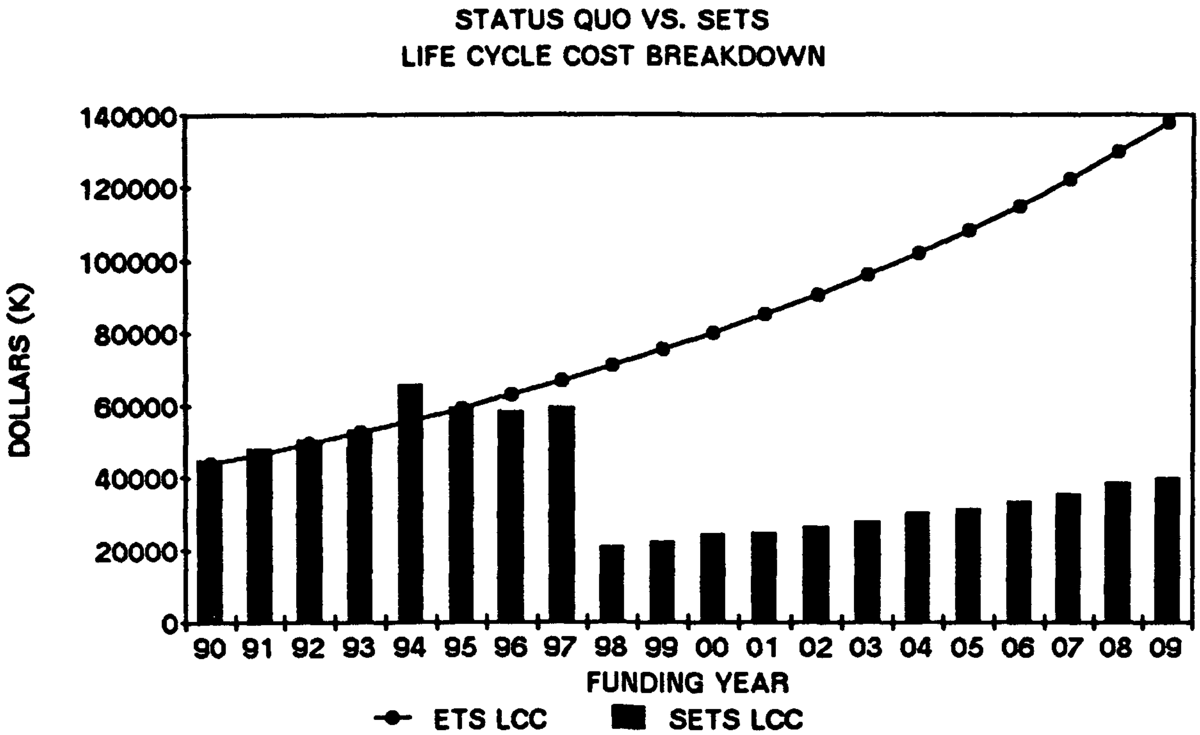


FIGURE 8

8. SETS TEST PLAN

The SETS has been demonstrated using a APU as the test engine. Future testing will be accomplished using a F-404 turbofan and T-700 turboshaft engines. In addition, a maintainability demonstration will be done. After the three engines are tested, the SETS will undergo TECHEVAL at Patuxent River. Results from the testing will be used to further validate the original LCC analyses done.

9. INITIAL FEEDBACK OF SETS LCC

Initial testing with the APU on the SETS indicated that the factors utilized to generate the LCC on the SETS were consistent with the results achieved. The SETS will provide a substantial savings on fuel. Because of the automated data acquisition system on the SETS, engine runs will not be as long. Warm-up time for the engine will also be shorter. At the present time,

the technical publication for the engine requires a five minute warm-up time for the engine. The instrumentation on the SETS shows that the engine actually stabilizes and is ready for testing after two minutes. A change to the technical publications will result in at least a three minute shorter run time for each test. It has also been validated that a two vice four person crew will be necessary to conduct an engine run. This will save considerable manpower. The data acquisition system will take all required data points for each engine automatically. This will save additional fuel.

Because the prototype SETS has been delivered and is on site at NAWCADLKE it will be easy to get additional LCC data. As NAWCADLKE is CFA for the SETS, additional information is readily available from the project engineer, logistician, TECHEVAL, maintenance demonstration, and First Article Test (FAT) report. This is the only reasonable and cost effective way to validate the SETS LCC. The following charts show the time frames and magnitudes of the main cost categories which require validation. Obviously, this will be a continuing effort. Figures 9 through 12 depict the results of the original LCC estimate.

SETS PREDICTED ACQUISITION COSTS

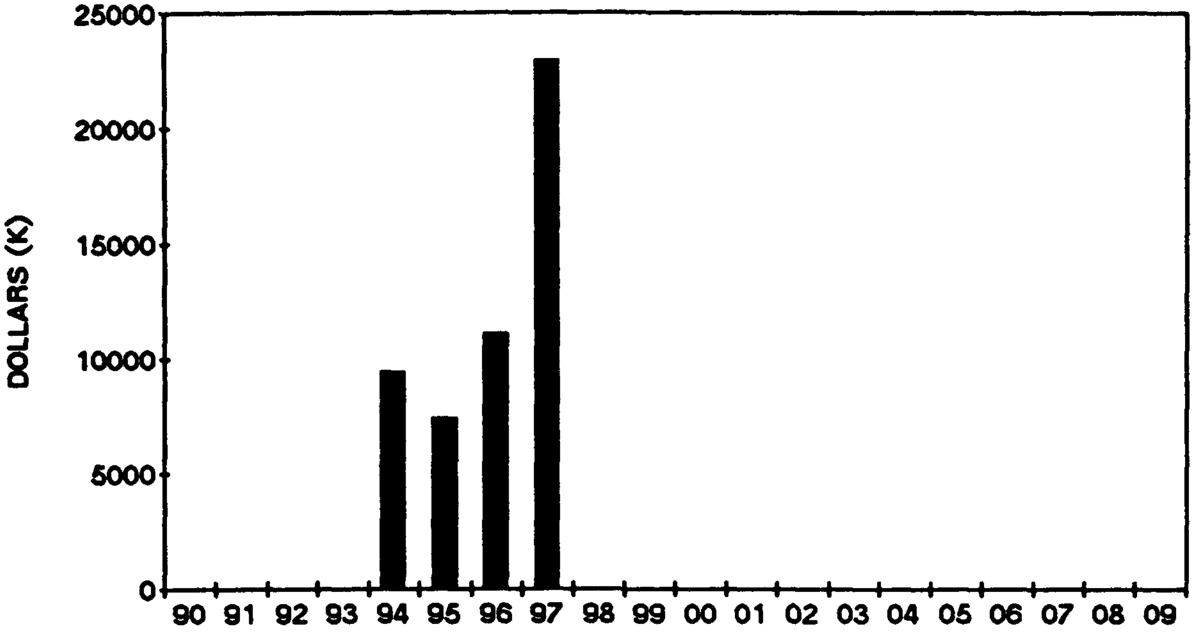


FIGURE 9

SETS PREDICTED SPARE COSTS

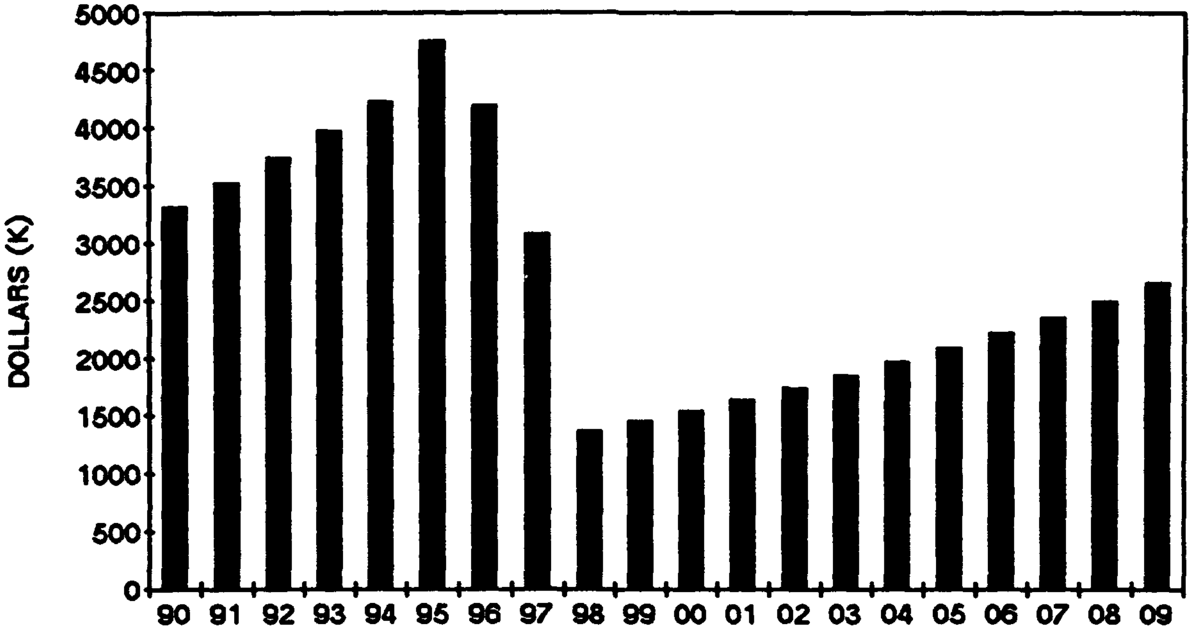


FIGURE 10

SETS PREDICTED MANPOWER COSTS

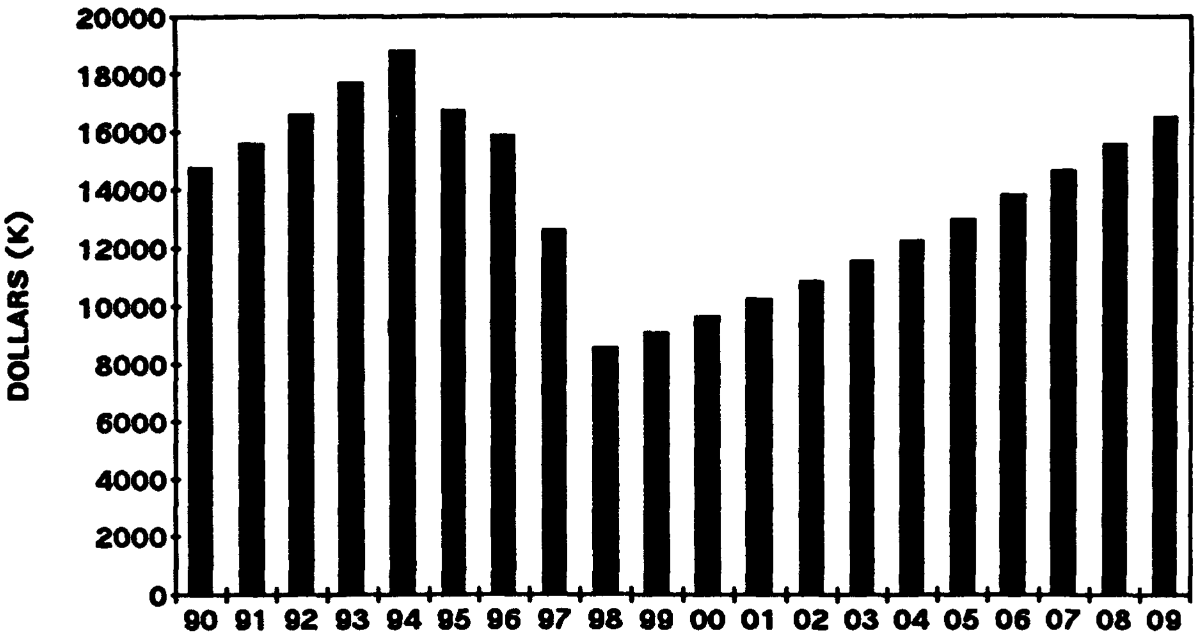


FIGURE 11

SETS PREDICTED FUEL COSTS

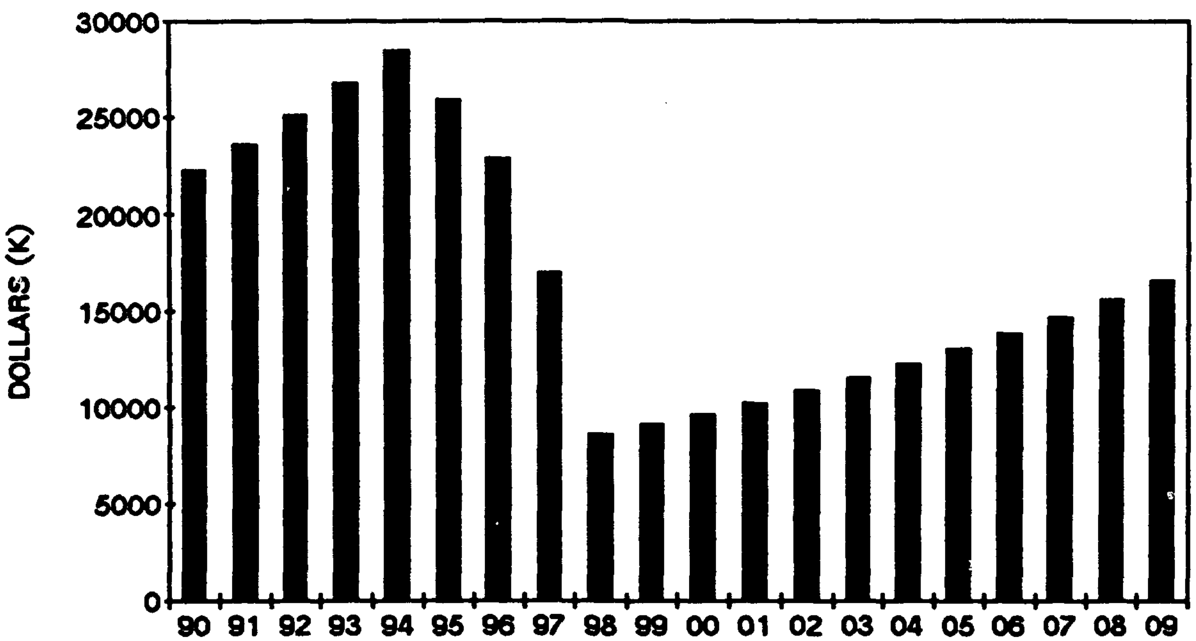


FIGURE 12

10. ANALYSIS & COMPARISON OF EXPECTED/ACTUAL LCC

Due to their relative importance, there are three main cost drivers in the LCC for the SETS which should be validated. They should be validated because they are the main cost drivers. In addition, they are easy to validate. Fuel costs for the APU were within an acceptable range of the initial estimate. As projected, manpower cost savings were realized by using a two vice four man crew for engine testing. This was validated during the APU testing. The estimated acquisition costs will be validated after final contract award. A recent contract award for SETS pre-production showed that the cost paid for each SETS was within 10% of the projected development cost.

11. LESSONS LEARNED

The LCC for the SETS was done in a cost effective manner because the cost analyst was on site where the engineering work was performed. The cost analyst was a specialist in Support Equipment (SE) and knew the technical personnel involved in the project. This gave the LCC analysis a shorter lead time with fewer errors. It also permitted the cost analyst to develop Cost Estimating Relationships (CER) for use on future SE LCC analyses.

It is important to keep the main focus on the follow up for the LCC analysis on the major cost drivers. In the case of the SETS, the authors selected the top three cost drivers. This will continue to be important in a period of a lack of funding and a shortage of qualified cost analysts.

Information gained from a similar Air Force program was invaluable in accurately determining LCC for the SETS. At the time that the LCC was performed, there was no existing Navy equipment to base the analysis on.

The initial testing reports were important in determining that the SETS LCC was on track. When the SETS is fielded, additional information can be derived from maintenance data for the test system and the actual engines. The FAT report provided additional valuable information to validate the SETS LCC analysis.

12. CONCLUSION

The LCC for the SETS was a main driver in the decision to go ahead with a new engine testing program. The LCC is a important tool to make intelligent management decisions. It is important to continue to validate each LCC as it is completed to ensure that the customer continues to receive good information.

The SETS program is also one of the first demonstrations of a successful LCC and SED process. It is important to remember that the LCC is an important input in the COEA.

There were no major discrepancies found in the SETS LCC. The authors estimate that 90% of work that should go into the LCC is the initial data gathering. It was easy to validate the LCC because of the relatively short lead time for SE. All the engineers and logisticians remain available to validate the LCC results because of the short lead time.

There is a need to continually validate the results for the LCC. Program managers should be encouraged to fund validations of each LCC performed. This will result in a continuous improvement of the LCC reports submitted. It will also foster pride in a job well done for the individual analyst.

APPENDIX A

METHODOLOGY OF ESTIMATE

The Parametric Review of Information for Costing and Evaluation (PRICE) cost model was used to estimate the development and production costs for the SETS, as well as the life cycle cost estimates for the SETS and the current ETS. Parametric is a computerized cost estimating system designed to calculate engineering and production factors. Application of the model requires obtaining input data based upon physical aspects of the item such as size and weight, qualitative aspects related to manufacturing complexities, other inputs based on procurement quantities, schedules, economics, engineering efforts and systems integration. Parametric cost estimating is used, both by contractors and the government, for several different purposes in acquisition planning and execution (ref. DCAA Contract Audit Manual 9-1002.3 1987). Parametric models have been used by U.S. Government agencies to estimate development/production cost, life cycle cost, and schedules since 1975. Expert opinion, mission requirements and historical information on similar test equipment (i.e. F107 Cruise Missile Program ATE RFQ Williams International GLB-ASE-6125) were also employed to compare technical and cost characteristics. In addition the Cost Analysis Strategy Assessment (CASA) model was also utilized as a supplement to estimate the life cycle cost of the SETS. The CASA is an analogy based cost estimating model which is a derivative of Honeywell's Total Resource and Cost Evaluation (TRACE) family of logistics and life cycle cost models.

APPENDIX B

ACRONYMS

ACRONYM	DEFINITION
ACAT	Acquisition Category
ADAPS	Automatic Data Acquisition and Processing System
APN	Aircraft Procurement Navy
APU	Auxiliary Power Unit
CA/E	Cost Analysis/Estimating
CASA	Cost Analysis Strategy Assessment
CDRL	Contract Data Requirements List
CER	Cost Estimating Relationship
CFA	Cognizant Field Activity
CMP	Cruise Missile Program
COEA	Cost and Operational Effectiveness Analysis
DCAA	Defense Contract Audit Agency
DoD	Department of Defense
ECM	Engine Control Module
ECU	Engine Control Unit
FAT	First Article Test
ETS	Engine Test System
FCM	Facilities Control Module
FY	Fiscal Year
GPH	Gallons Per Hour
GPM	Gallons Per Minute
GTC	Gas Turbine Compressor
I	Intermediate
I&C	Instrumentation and Control
ICATS	Integrated Computer Automated Test System
ILS	Integrated Logistic Support
ILSDS	ILS Detail Specification
LCC	Life Cycle Cost
LSA	Logistic Support Analysis
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
NAWCADLKE	Naval Air Warfare Center Aircraft Division Lakehurst
OJT	On Job Training
PC	Personal Computer
PEMP	Program Element Master Plan
PR	Purchase Request
PRICE	Parametric Review of Information for Costing & Evaluation
RAMS	Reliability, Availability, Maintainability, Safety
SECM	Soft Engine Control Module
SED	Support Equipment Decision
SETS	Standard Engine Test System
SML	Support Material List
TIP	Total Items Processed
TLRN	Technical Logistics Reference Network
TRACE	Total Resource and Cost Evaluation

A P P E N D I X   C

LIFE CYCLE DEFINITIONS

Development cost - engineering design; design documentation; reliability and maintainability; quality assurance; data; software; test and evaluation of prototype; and associated management functions.

Production cost - manufacturing cost; production operations; quality control; logistics support requirements; and associated management functions.

Operational and support cost - operation of the system in the field; logistic support; supply; transportation and handling; technical data; facilities; training; modifications; etc.

Disposal and retirement - disposal of non-repairable items; retirement of the system.

Equipment/Development - The equipment development cost is a summation of research and development costs, including design, drafting, systems engineering, project management, data submittals, prototype development and fabrication, engineering shop tooling, and test equipment. The engineering data primarily consists of the standard maintenance and operating manuals, and the usual Contract Data Requirements List (CDRL) data requirements.

Equipment/Production - The equipment production cost includes the total acquisition cost of all equipment deployed over the life of the program and the non-recurring production costs. The equipment unit cost is a function of the average recurring production cost, the reference quantity, the learning-curve effect, and the total quantity of equipment deployed plus initial equipment spares. Production for the SETS is scheduled to start in 1994. 132 SETS are proposed to be built.

Supply Spares and Repair Parts - Spare parts are defined as product for separate production and procurement that are required for maintenance or repair. This would exclude end items which have redundancy designed into the product to avoid failure. Spare parts could range from piece parts to minor assemblies to end items. They are procured from the manufacturer to replace like equipment that is lost from the program as a result of scrap or attrition. Initial spares are procured concurrently with the production of the basic equipment. All parts are considered non-repairable and therefore they are handled as scrap. Production scrap and waste are not included in spare parts.

Supply Administration/Production and Support - The supply administration cost for production is the cost to enter new spare items into the supply system. The items may include non-standard parts, module types, and equipments. The supply administration cost for support is the cost to retain new items mentioned above in the supply system over the life of the program. Using the value acquired from the Naval Air Systems Command Default Data Guide, the cost to enter new spare items is $701.00 and the cost to retain them is $199.00.

Manpower and Corrective Maintenance - The manpower cost for support is the cost of labor required for set-up, take-down, calibration, operating and maintaining the equipment over the life of the program. It is assumed that each technician is assigned exclusively to one system. The labor rates are assigned to the location at which the maintenance is performed without regards to the rank or skill of the technician. For a team of operators and technicians, the labor rates should be multiplied by the number of people per team.Preventive Maintenance

Supply Facility - The supply storage costs are based on the monthly storage rates and the supply hardware volumes. It would cost $0.60/cuft/mo to store spare modules or parts in the land-based and carrier-based maintenance levels.

Shipping - The shipping costs are computed from the weight of each stock item shipped and number of trips. Repairable equipments and modules are charged for a return trip while balance consumed spares are charged only for one way trips from the manufacturer down towards the equipment level. The only shipping cost to be considered for the SETS is the cost to ship the units from the Contractor to the Equipment Location. The costs to ship the units from one maintenance location to another is not relevant.

Contractor Support and Training - The contractor support cost is generated by using the following cost factors: (1) contractor cost for equipment; and (2) contractor cost for module repair. The contractor support cost for technical evaluation will primarily involve the cost to correct any flaws found in the system. The remainder of the training process will be an On Job Training (OJT). The OJT cost is included in the manpower cost. However, due to normal attrition and the fact that an operator may decide not to re-enlist in the service, consideration must be taken as to the number of new operators to be trained for this particular system. There is an operator turnover every three years. Therefore, it can be concluded that the yearly turnover rate is 33%. The plans and report on personnel and training manpower are included in the development phase. The cost incurred in this category is part of the Contract Date Requirements List (CDRL).

Modifications/ECP's - It is anticipated that there could be three modifications for the SETS to make allowance for new technology

and software upgrades. The modifications/ECP's are expected to take place in the 6th, 10th, and 14th year after production ends.

Additional Software Program - The software program cost includes the development of software for additional engines. The CA/E Office estimated 2 man-years per year as a basis for the cost from year 1995 to 1999, and 1 man-year per year from year 2000 to 2009.

Integrated Logistics Support Monitor - An estimated cost of $400,000.00 APN-7 funding would be required to properly review and verify all the ILS items throughout the development phase and the first year of production prior to their acceptance by the Navy.

A P P E N D I X   D

SETS ASSUMPTIONS

AREAS OF CONSIDERATION

The initial shipping cost for the SETS prototype is $35K; this value was obtained from the ASE estimate. The majority of the shipping cost is shown concurrently with the production of the SETS. The cost involves shipment of the SETS and cables from contractor to their designated destinations. The remainder of the shipping cost is the cost to ship spares modules and parts.

It is assumed that all maintenance actions will be done by military personnel. An average maintenance action takes 1.5 hours with an estimated preventive maintenance of four (4) per month.

On-Site Calibration - A calibration team will be contracted by the Navy to perform an on-site calibration test on each test cell every 6 months which produces 2 calibrations in one (1) year for one (1) cell. Each test would cost $3000 as per the Technical Evaluation Facility from Patuxent River.

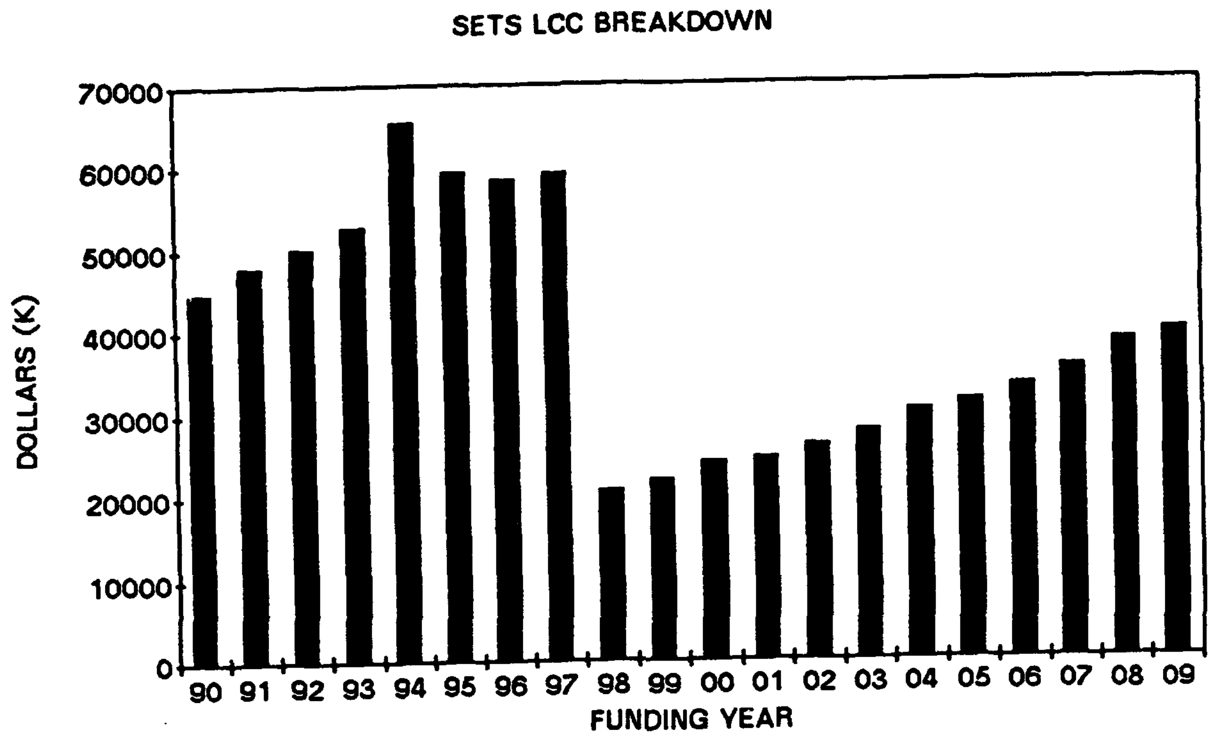
The SETS will be used at I level aviation maintenance activities worldwide, both ashore and afloat, to automatically control out-of-airframe engine test runs. There will be two operators assigned per test cell. Class E-5 and above operators will be paid $12.36/hr to operate the SETS. This labor rate is a weighted average rate obtained from the Naval Air Systems Command Default Data Guide. Regular military personnel will be maintaining the systems; a repair cost of $12.36/hr is applicable to the intermediate levels. The labor rate for civilian is $56.78/hr for depot rework. Maintenance cost includes preventive and corrective maintenance.

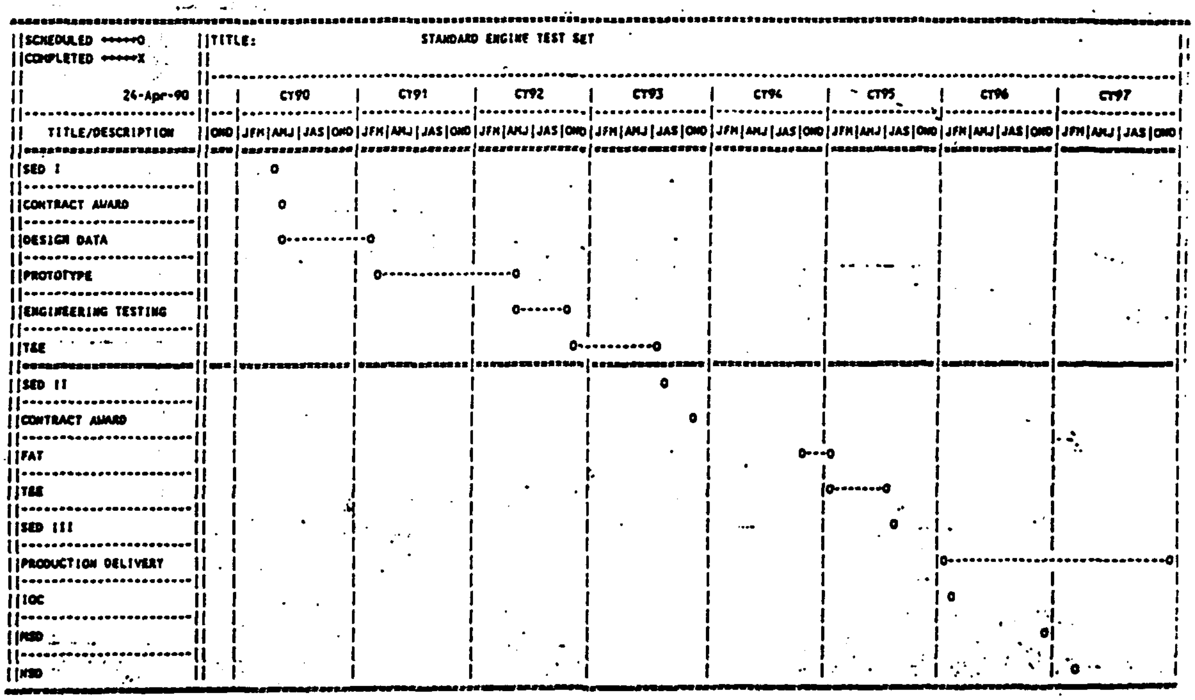
Reliability and Maintainability - Based on an estimate by ASE, the Mean Time Between Failure (MTBF) of the SETS should equal or exceed 1680 hours, with a Mean Time To Repair (MTTR) of approximately one hour assuming that the Navy spares the major assemblies and modules. Clifford Ash, of ASE has guaranteed the MTBF of 1680 hours given to the CA/E Office for this cost estimate will meet or exceed the acceptance requirements.

Usage Rate - An usage rate of 131 hours per month for the SETS based on the program manager's estimate was utilized for the life cycle cost calculation.

Disposal Cost - It is assumed that all SETS will still be in service at the end of the life cycle cost analysis period. Therefore, the disposal cost is not a factor in the estimate.

Inflation Rate - An inflation rate factor of 6.2% was applied in the estimate for the years of operation and support period. For the calculation of the factor the Consumer Price Index, the Producers Price Index, the International Monetary Fund, McGraw-Hill Data Resources Inc., and the Federal Reserve discount rate were used as sources.





APPENDIX E

ETS ASSUMPTIONS

Analogy Cost Rational - The following Engine Test Systems (ETS) have been used as a basis for the life cycle cost of the existing ETS. Through the Technical Logistics Reference Network (TLRN) and the logistics group, it has been concluded that these ETS information are accurate and may be used as a guide for the life cycle cost analysis of the existing ETS.

As part of the life cycle cost and value analysis, the CA/E office utilized four specific existing test systems to represent each of the four major engine test disciplines. Each specific system was carefully selected as representing the most current state of the art technology utilized by the Navy today. In addition, current purchase prices as well as maintenance and support parameters were also utilized in the development of the cost to operate the existing systems. The following test systems were chosen as benchmarks representing the major categories:

APU TESTING: The A/E37T-26A Auxiliary Power Unit (APU) test stand was utilized as a baseline data reference for all APU test systems. As one of the newest and most up-to-date APU testers the T-26A has the most current technology of any APU tester utilized today in the Navy. All external components/modules such as cables, hoses and fuel skids associated with the T-26A would be considered as usable with the SETS. Current replacement costs for the A/E37T-26A as listed in the Technical Logistics Reference Network (TLRN) in 1990 dollars is $168,000.00, various adaptor assemblies are also utilized in the T-26A and appear to average $50,000.00 each. An allowance for the adaptor assemblies of $100,000.00 per system would bring the replacement cost of a A/E37T-26A test system to $268,000.00 each in 1990 dollars.

TURBOSHAFT TESTING: The A/E37T-24 Turboshaft test system was utilized as a baseline data reference for all turboshaft engine test systems. The test system is available in four basic configurations. All configurations include an instrumentation and control (I&C) cab assembly, a fuel and oil system installation, an engine test trailer, a junction box, and various hoses and cables for interconnecting system components. With peculiar adapters, which are not supplied as part of the basic system, the T-24 can be used to test the T-64, T-400, T-58, and the T700 engines. The T-24 was used as a representative turboshaft test system for the analogy estimate because of the types of engines it supports, and the ability to derive realistic MTBF, MTTR, and other data on the system. All external components associated with the T-24 would be considered as usable with the SETS. Current replacement costs for A/E37T-24 test system as listed in the TLRN in 1990 dollars is $499,000.00 dollars each ($214,000 for the I&C cab, $40,800 for the fuel system, and $245,000 for the test trailer).

TURBOJET/FAN TESTING: The A/M37T-23 Mobile Engine Test System was used as the baseline data reference for all turbojet/turbofan test systems. The T-23 provides complete functional and operational testing of turbojet/fan engines in the Navy inventory using the latest in precision electronic instrumentation. The instrumentation package components in the T-23 are identical to those in the T-10 and T-14 test systems, although packaged differently for optimum mobility. Therefore, the instrumentation packages and adapter assemblies are compatible in general. All external components associated with the T-23 would be considered as usable with the SETS. Current replacement costs for the A/M37T-23 as listed in the TLRN in 1990 dollars is $445,000.00. This cost is for the complete system including the I&C cab, fuel system, runup trailers, and all additional equipment required to operate the test system.

TURBOPROP TESTING: The A/E37T-17 turboprop engine test system was used as the baseline data reference for all turboprop test systems. The basic test system consists of an instrumentation and control (I&C) cab assembly, a fuel skid and a new or modified Allison engine test bed and engine adaptor assembly. All external equipment and components associated with the T-17 would be considered as usable with the SETS. Current replacement costs for the A/E37T-17 test system as listed in the TLRN in 1990 dollars is $228,000.00 per unit. The actual cost breakdown for the system is $102,000.00 for the I&C cab, $38,000.00 for the fuel system, and $90,000.00 for the engine test bed.

OPERATIONAL COSTS - In order to develop operational costs, a weighted average MTBF of 680 hours and a MTTR of 2 hours were utilized for the life cycle cost analysis of the existing ETS. All corrective and preventive maintenance actions have been considered as well as semi-annual calibrations. Usage rates have been derived from 3M, various field activity logs, and interviews which were then utilized to estimate the life cycle costs. Disposal cost will not be a factor as old test cells would be utilized as spare supply or as sale to foreign country.

Supply Spares and Repair Parts - The Navy is responsible for the storage of the spare parts. At the same time, they will procure spares in accordance to the needs of the Navy. This would lessen the costs in both storage and procurement. Spares will be procured throughout the life of the test set. It is estimated that the yearly spares cost is approximately five percent (5%) of the end item cost.

Supply Administration/Production and Support

The cost for supply administration starts as soon as the supply spares and repair parts are procured, and it goes to the end of the study which is the year 2009. The cost to enter these items in the supply system is $701.00 each item. The cost to retain each new item in the supply system is $199.00. These values are acquired from the Naval Air Systems Command Default Data Guide.

Manpower and Corrective Maintenance

The existing units are used at intermediate-level aviation maintenance activities worldwide, both ashore and afloat, to automatically control out-of-airframe engine test runs. It is assumed that there are four (4) operators assigned to each test cell. The operators are classified as Class E-5 and above. The weighted average labor rate for both the carrier-based and land-based operators is $12.36. The labor rate was obtained from the Naval Air Systems Command Default Data Guide. On-the-job (OJT) training is included in the manpower cost.

The historical engine test time for an ETS is 4.3 hours per engine based on a weighted average determined by an extensive data search. 20 tests/mo/cell for 279 cells equals to 66,960 engines tested. The number of test performed by carrier based ETS have not been listed completely; therefore, the approximate usage rate has been calculated using the information presented for the land-based ETS.

Regular military personnel will be maintaining the systems; therefore a repair cost of $12.36/hour is still applicable to the intermediate level. This rate is also obtained from the Naval Air Systems Command Default Data Guide. In case a module cannot be repaired in the maintenance level, the module will be sent to the depot level which is a highly specialized repair facility. It is assumed that maintenance personnel and spares are on hand.

Preventive Maintenance

It is assumed that all maintenance actions will be done by military personnel. An average maintenance action takes 1.5 hours with an estimated preventive maintenance of 4 per month.

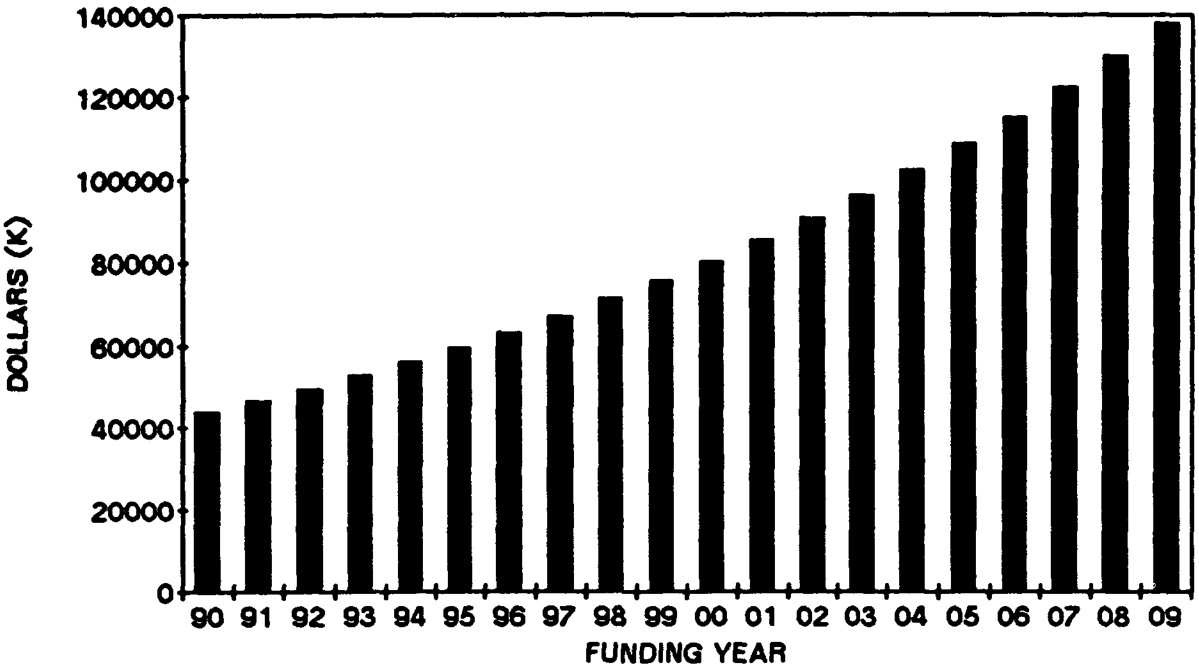
On-Site Calibration

A calibration team will be contracted by the Navy to perform an on-site calibration test on each test cell every 6 months which produces 2 calibrations in one (1) year for one (1) cell. Each test would cost $3000 as per the Technical Evaluation Facility from Patuxent River.

Supply Facility

The cost to store spare modules and parts on land or on board is approximately $0.60/cuft/mo. This figure was acquired from the Naval Air Systems Command Level of Analysis Default Data Guide.

STATUS QUO LCC BREAKDOWN



SOURCES CONSULTED

NAEC Design Data Report No. 52-736

NAEC Design Data Report No. 52-742

NAEC Miscellaneous Report No. 52-0993 dated 09 Apr 90

NAEC Miscellaneous Report No. 52-0993 Revision dated 15 Feb 91

NAEC Report NAEC-MISC-52-1055